

DESIGN AND PERFORMANCE REVIEW OF INNOVATIVE MICROWAVE INDUCTIVELY COUPLED ATMOSPHERIC PLASMA - OPTICAL EMISSION SPECTROSCOPY (MICAP™-OES 1000) FLEXIBLE SAMPLE MATRIX AND FULL SPECTRUM ACQUISITION

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NO ARGON. NO CHILLER. NO PROBLEM!

MICAP-OES 1000



Smarter. Faster. More efficient.

Radom's proprietary Cerawave™ technology sets a new standard for productivity. Cerawave replaces water cooled coils and traditional RF generators. MICAP-OES 1000 is a powerful analytical instrument with a simple design eliminating the need for a chiller and permanent installation location.

Introduction

Due to the power, exhaust, weight and gas supply constraints, traditional high performance atomic spectroscopy instruments are designed for laboratory use.

MICAP-OES 1000 operates on industrial grade (99.9%) nitrogen and 1000 W power. The technology to create the stable plasma is called Cerawave™ which replaces the traditional water-cooled coil RF generators. The design of a light-weight modular component microwave plasma with an echelle-based spectrometer provides real-time full spectrum elemental fingerprint wherever needed.

MICAP-OES 1000 is the frontline defense to capture critical elemental information, providing results for quick decisions in environmental monitoring, mining exploration and manufacturing processes.

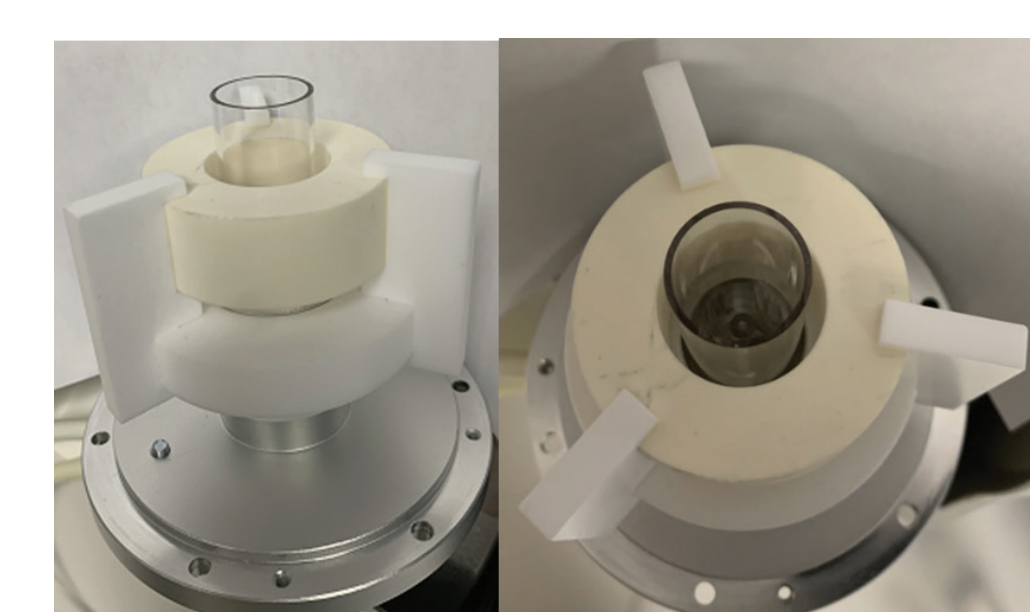
Current Commercial Optical Emission

Traditional inductively coupled plasma generated with Water Cooled Copper Coil RF generator frequencies 27MHz or 40 MHz

Type	Purity Range (%)	Operating Pressure Ranges (PSI)	Operating Flow Range (L/min)		
Gas	Argon	70 to 109	9 to 26		
	Nitrogen	70 to 109	1.5 to 14		
	Sheer Air	Compressed air	80	28	
Width Range (in)	Height Range (in)	Depth Range (in)	Weight Range (lb)	Power Specification	
Physical Specifications ICP-OES only	24 to 46	34 to 37	27 to 29	176 to 326	200 - 240 V 15 to 20 amp
Chiller	Cooling (°C)	Power Range (W)	Size WxDxH (in)	Typical Weight (lb)	Power Specification
	10 - 30	> 750 to 2000	15 x 27 x 24	178 to 190	208 - 230 V 15 amp

Microwave Inductively Coupled Atmospheric Plasma - Optical Emission Spectrometer 1000

Type	Purity Range (%)	Operating Pressure Ranges (PSI)	Operating Flow Range (L/min)		
Gas	Nitrogen*	50 - 70	18L/min		
	Sheer Air	Compressed, dried air	50 - 70	20L/min	
	Argon	99.995	60 - 70	During ignition sequence only	
Width Range (in)	Height Range (in)	Depth Range (in)	Weight Range (lb)	Power Specification	
Physical Specifications ICP-OES only	24	29	20	67	208 - 240V * 120V
Chiller	No Chiller				



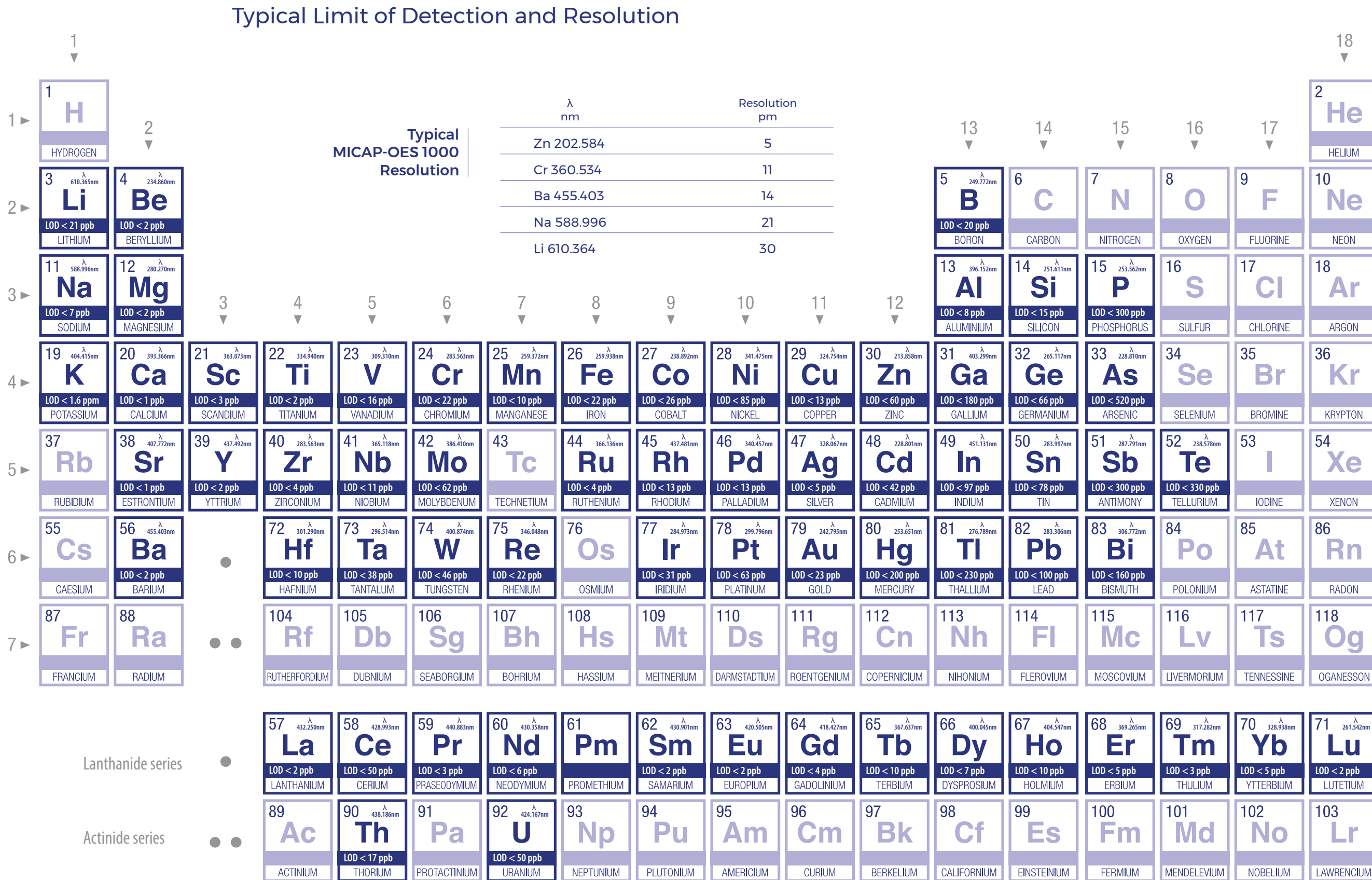
Torch installation assembly: Easy to use and reproducible set up. Axial viewed plasma with automated plasma tail removal, no optimization required.

Echelle spectrometer with CMOS camera, measures the entire wavelength range with every solution injection.



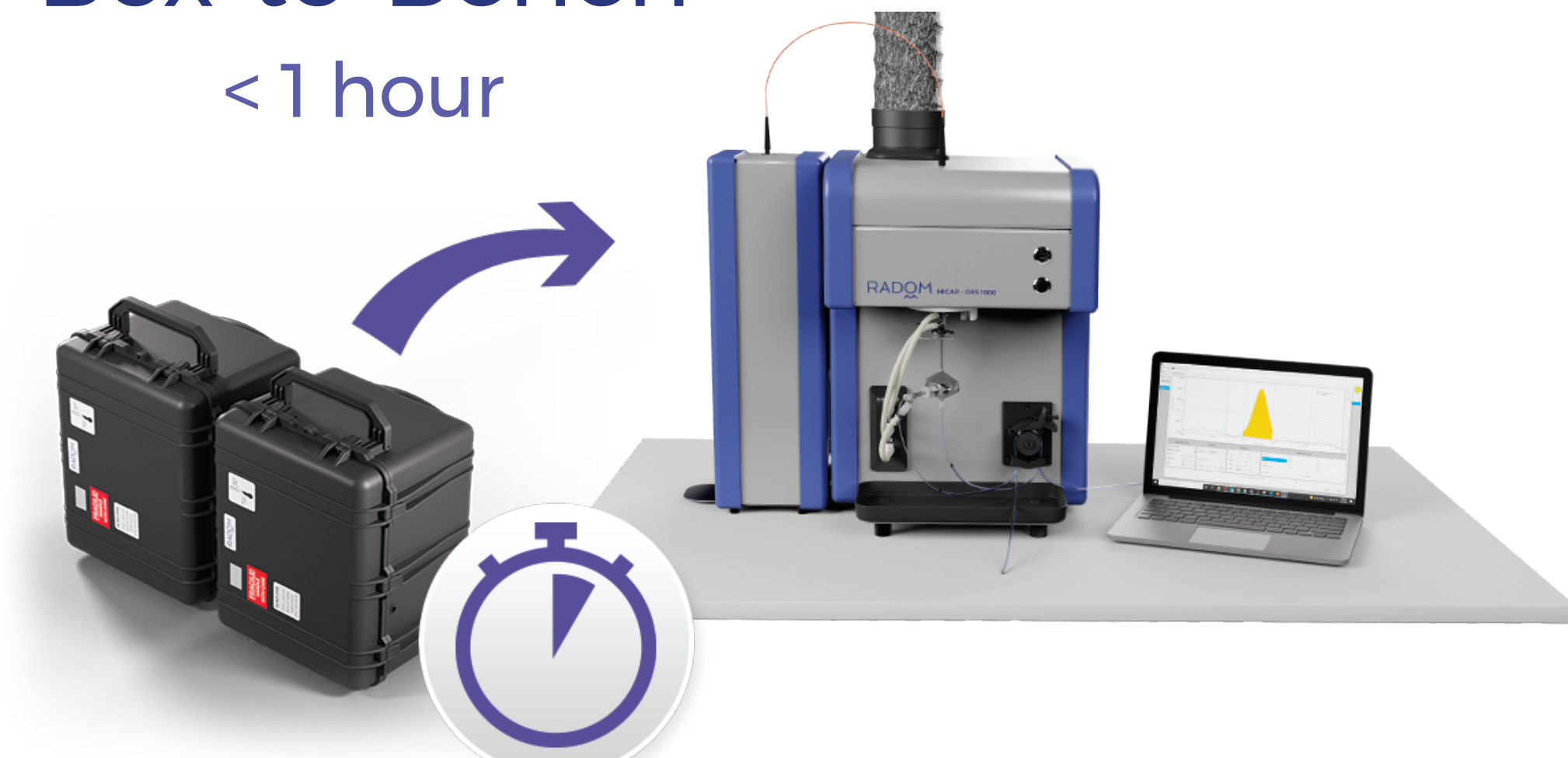
Aperture: f/10
Wavelength range: 194 nm - 625 nm
Simultaneous: up to 625 nm
Slit Width: 30 um slit
Resolution: 5pm - 30 pm

MICAP™-OES 1000



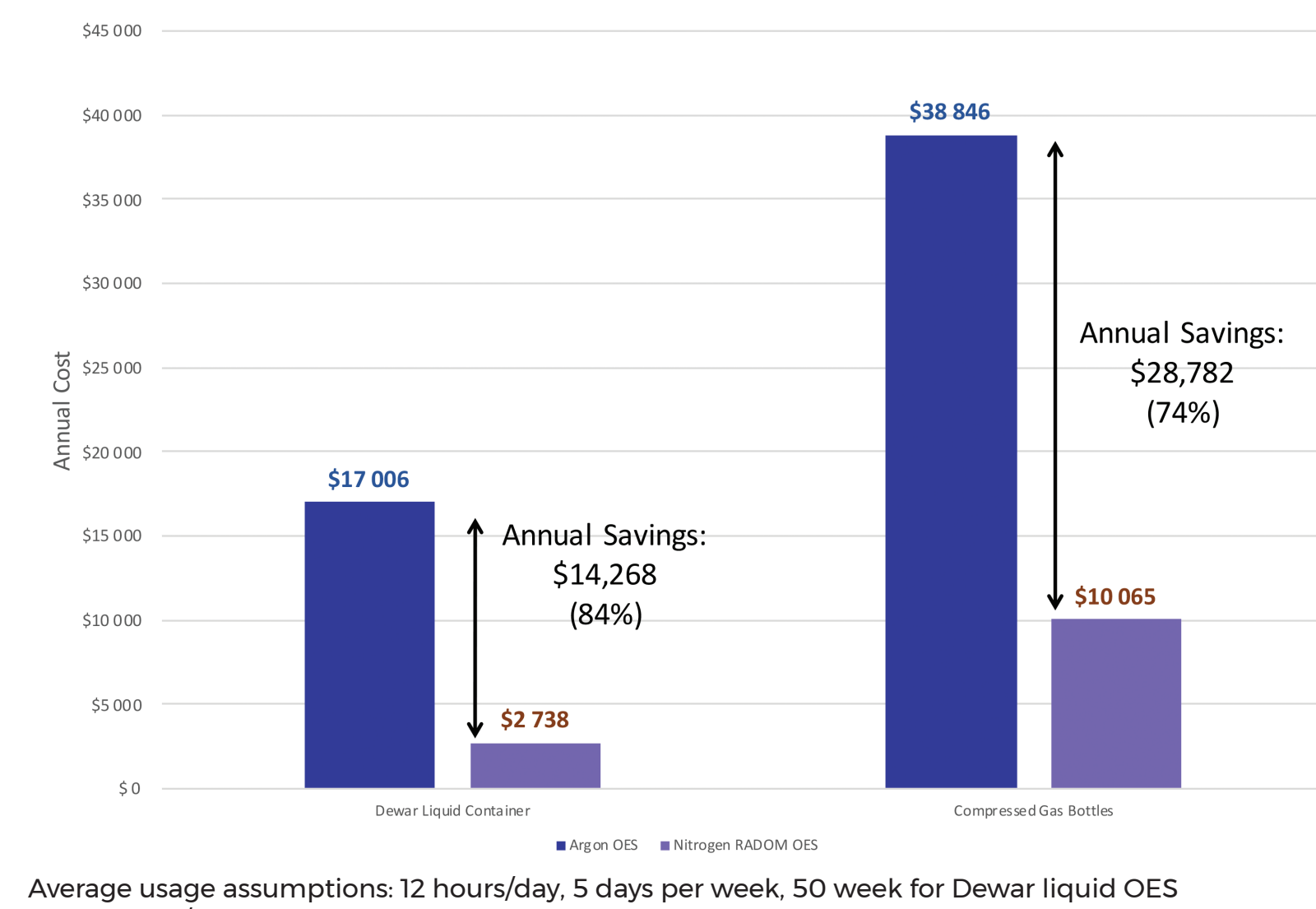
CERAWAVE BENEFITS FOR MICAP-OES 1000

Box-to-Bench <1 hour



Nitrogen technology

- Advantages of using nitrogen gas source:
 - Less expensive to operate
 - Readily available
 - Safe to use



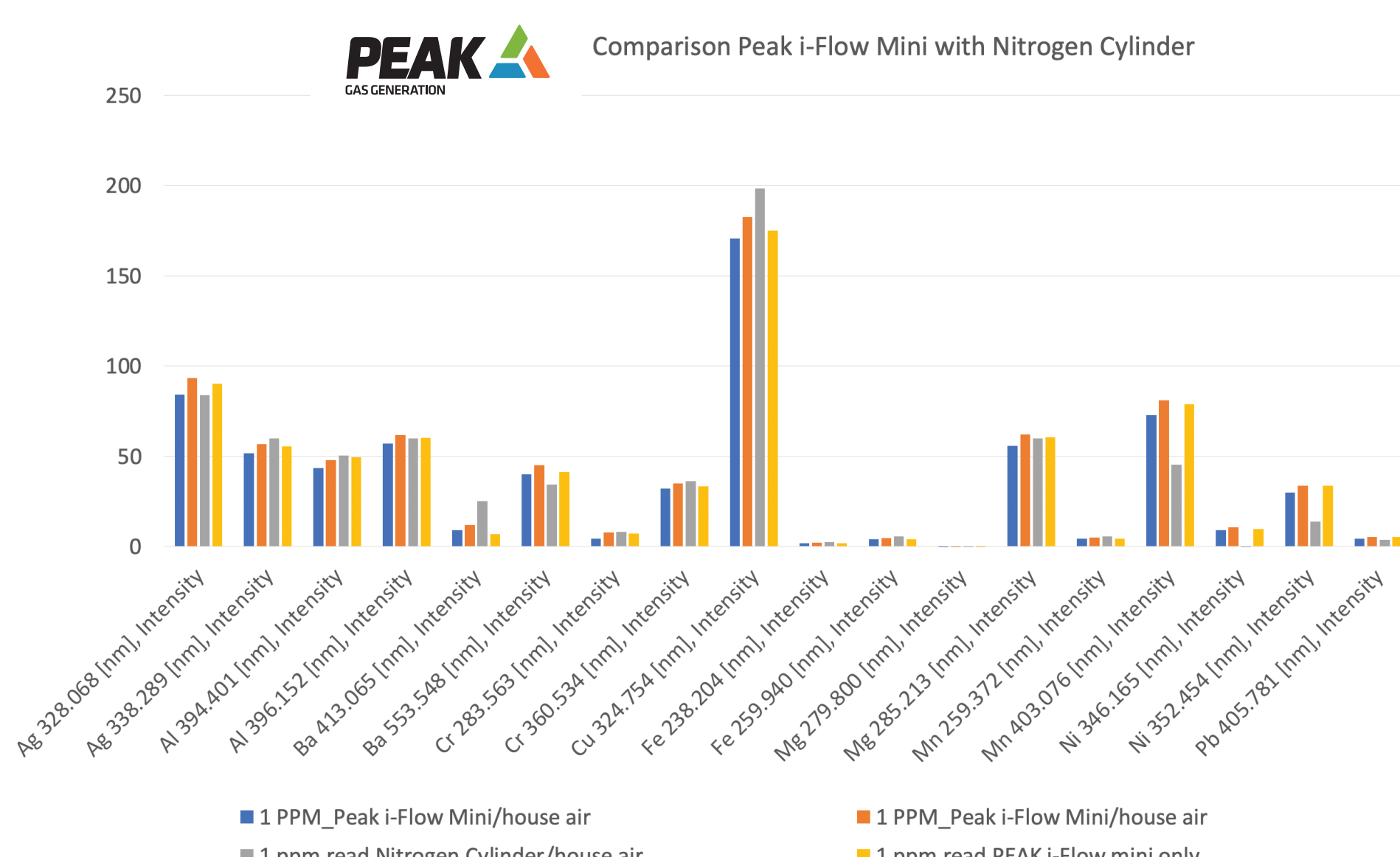
Nitrogen can be generated from air. PEAK i-Flow Mini provides uninterrupted analyses and increases productivity.

Lowest Carbon Footprint

MICAP-OES 1000 has the lowest carbon footprint of any OES instrument in the market.

Annual CO₂e Emissions Savings Compared to Argon

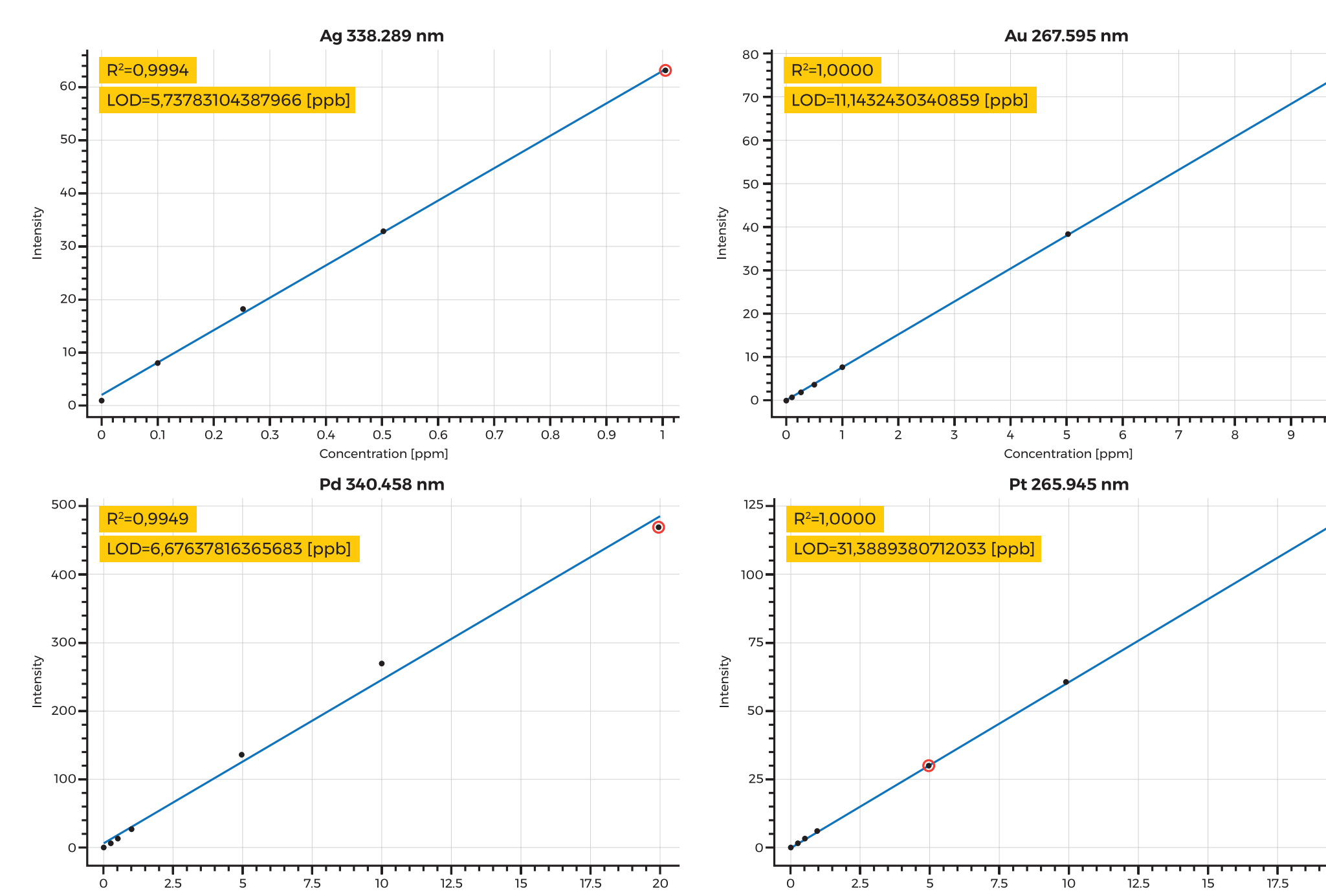
Category	Value
KWh saved	239,850
metric tons of CO ₂ e saved	170
Equivalent to:	
Homes' annual electricity use	33
Gasoline-powered passenger vehicles	37
Total gallons of gasoline consumed	19,127
Total smartphones charged	20,676,512



Mining and Minerals Matrices

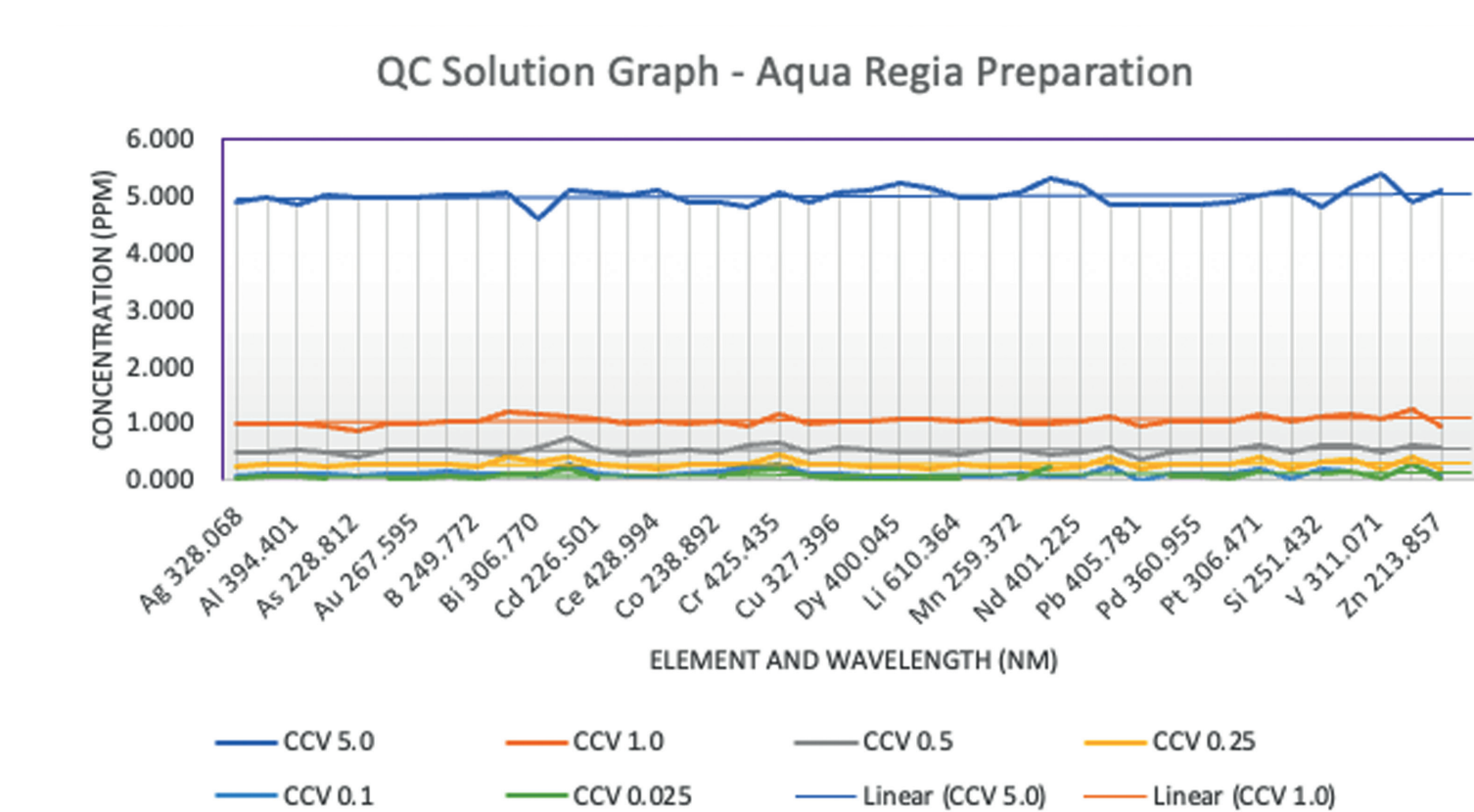
OREAS CRM results for gold in aqua regia digestions

Analyte	Wavelength	CRM ID	Certified Value	Preparation 1	Preparation 2	Dilution	Recovery 1	Recovery 2
Au, ppm	267.595	238	2.95	2.99	2.84	1x	101%	96%
		242	8.33	6.95	7.28	1x	83%	87%
		255b	4.08	3.82	3.77	1x	94%	92%
		256b	7.58	7.61	7.13	1x	100%	94%
			14.17	14.55	15.42	1x	103%	109%



OREAS CRM 2560 Result Summary

CRM ID	Wavelength	Certified Value	Preparation 1	Preparation 2	Dilution	%REC 1	%REC 2
2560	528.286	135	131	130	164	50x	98%
2560	578.205	174	170	164	164	50x	98%
2560	589.022	267	265	265	265	1x	100%
2560	630.555	62	62	62	72	1x	100%
2560	844.621	36.8	36.8	36.3	36.3	1x	100%
2560	880.686	18.8	23.5	18.8	1x	100%	95%
2560	880.686	175	194	188	1x	100%	107%
2560	925.766	81	825	102	1x	100%	123%
2560	238.204	5.45	5.27	5.28	100x	95%	95%
2560	280.277	1.25	1.29	1.28	50x	104%	103%
2560	293.372	0.027	0.027	0.028	20x	102%	95%
2560	589.022	0.158	0.156	0.162	100x	98%	103%
2560	430.337	16.6	17.5	17.1	1x	100%	103%
2560	365.059	62	61	62	1x	100%	100%
2560	525.975	3.84	4.5	4.3	1x	100%	112%
2560	442.454	5.21	5.65	5.81	1x	100%	109%
2560	489.862	5.52	5.5	5.48	1x	100%	98%
2560	524.451	0.662	0.668	0.668	50x	100%	100%
2560	289.332	57	59.4	58.3	1x	104%	102%
2560	424.445	17.8	18.5	17.2	1x	94%	92%
2560	360.075	7.76	7.50	7.18	1x	97%	93%
2560	203.548	59	63	63	1x	107%	104%



To prepare the CRM samples, ~2 gms of each CRM was weighed into a 50-mL graduated DigiTube (SCP Science). To each weighed sample, 2mL nitric acid (HNO₃), 6mL hydrochloric acid (HCl) and 20mL Type I water was added. A single-use polymeric watch-glass was placed on each tube. A digestion blank prepared as the samples was included with each preparation set.

The test solutions were refluxed for 2 hours at 95°C utilizing the DigiPREP Jr (50mL). The test samples were allowed to cool to ambient temperature, diluted to 50-mL with water and filtered with 1.0 µm hydrophilic Teflon®.

Organic Solvents Premisolv™

Lubricating Oil Analysis

Diluent = Premisolv™ ICP Solvent (Cat# 150-700-000)
Blank Oil = 75c-St (Cat # 150-075-002)
Standard = S-21 (Cat # 150-021-003)
Ag, Al, B, Ba, Ca, Cd, Cr, Cu, Fe, Mg, Mn, Mo, Na, Ni, P, Pb, Si, Sn, Ti, V, Zn and K

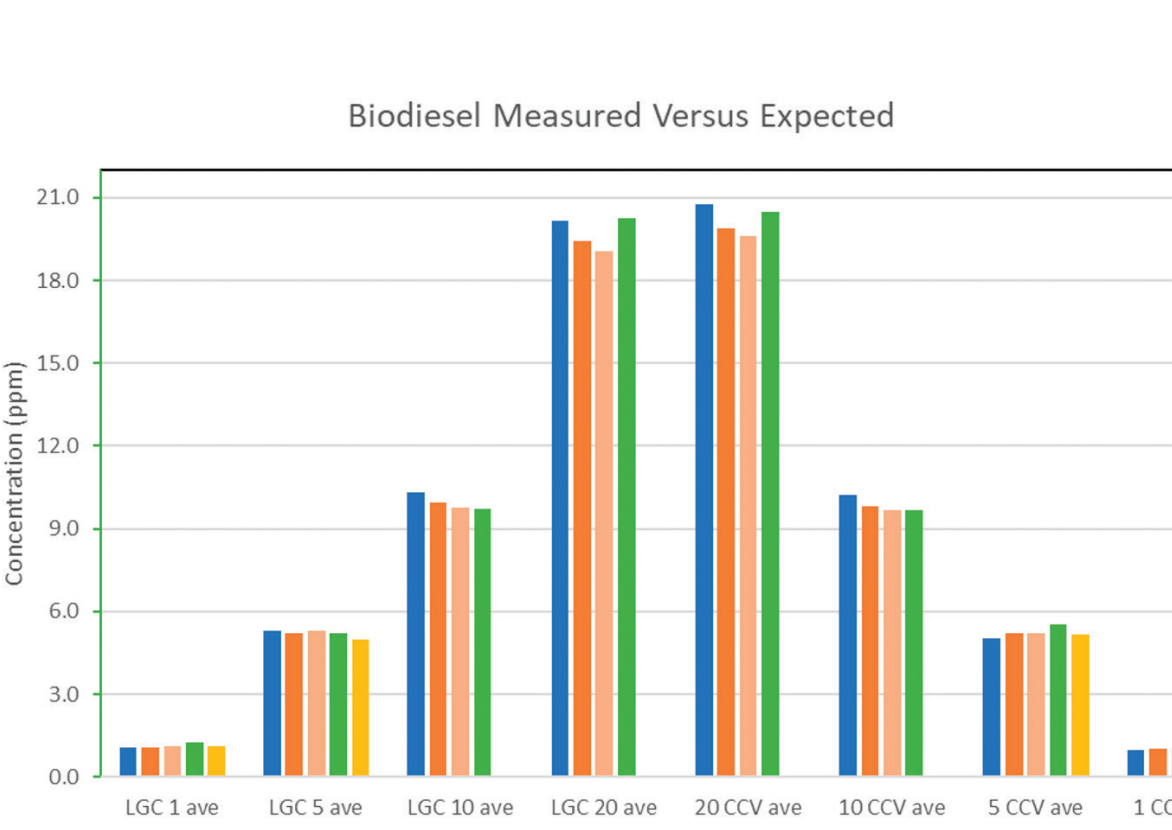
EnviroMAT™ Used Oil Lot No: S140916011
SCP Science (Cat # 140-025-041)

Unknown in-service oil, synthetic oil from a 2006 Dodge Durango (150,000 service).

Element	Wavelength	MICAP-OES Readback	Concentrate Value	Confidence Interval	Reference Method
Ag	328.072	255	260	218-293	201-292
Al	844.621	8.9	9.2	8.1-10.4	11.2-12.2
As	209.812	94.9	82.1	81-209	82-208
Ca	854.302	18.9	19	18-20	18-20
Co	512.226	508	492	492-512	502-502
Cr	267.716	642	642	642-642	642-267
Cu	327.404	107	103	103-103	124-243
Fe	248.330	207	189	189-207	189-207
K	766.491	62	62	62-62	62-62
Mg	789.019	36.8	36.1	36.1-36.1	32-32
Mn	279.543	64.0	62	62-62	62-62
Mo	285.283	20.3	21	21-21	21-21
Ni	192.781	103	103	103-103	103-103
Pb	220.353	20.3	20.3	20.3-20.3	20.3-20.3
P	213.617	103	103	103-103	103-103
Si	352.941	528	528	492-508	508-707
Sn	337.073	103	103	103-103	103-103
Ti	334.947	103	103	103-103	103-103
V	208.987	103	103	103-103	103-103
Zn	213.811	103	103	103-103	103-103

Biodiesel Analysis

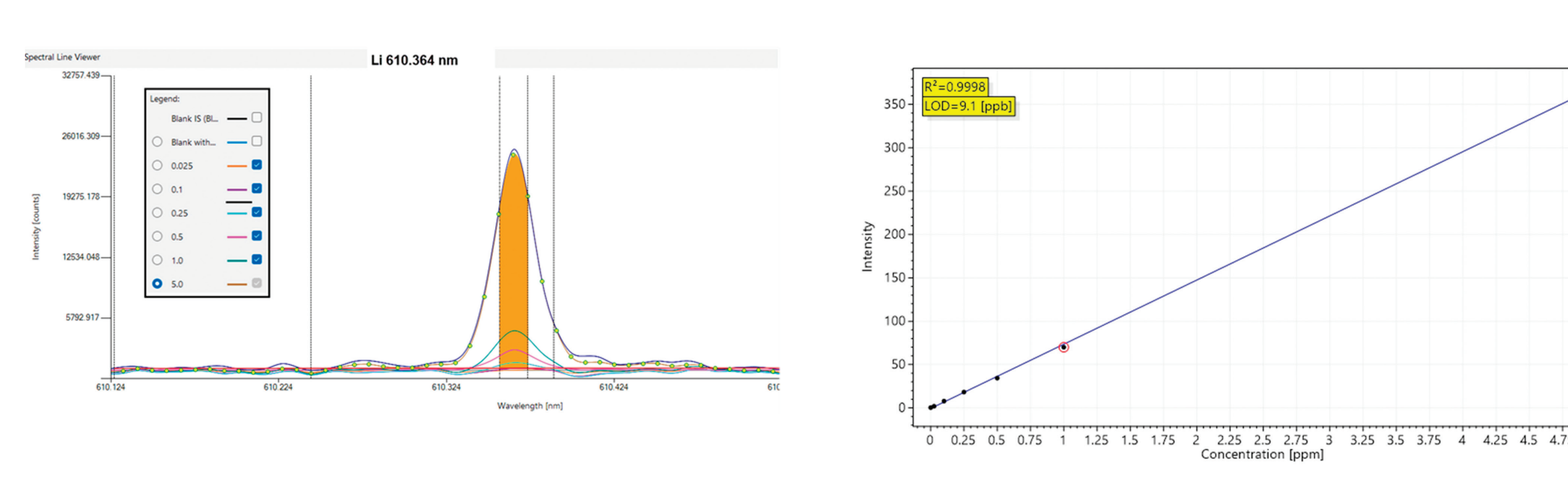
Element	Wavelength	Concentration	Reference Method
Ag	328.072	255	260
Al	844.621	8.9	9.2
As	209.812	94.9	82.1
Ca	854.302	18.9	19
Co	512.226	508	492
Cr	267.716	642	642
Cu	327.404	107	103
Fe	248.330	207	189
K	766.491	62	62
Mg	789.019	36.8	36.1
Mn	279.543	64.0	62
Mo	285.283	20.3	21
Ni	192.781	103	103
Pb	220.353	20.3	20.3
P	213.617	103	103
Si	352.941	528	528
Sn	337.073	103	103
Ti	334.947	103	103
V	208.987	103	103
Zn	213.811	103	103



Glass Expansion 0.2µm/min Micromist nebulizer
Double pass cyclonic spray chamber, 2.5mm injector torch

- Class Expansion
- IsoMist XR programmable temperature-controlled spraychamber
- Set point = (-5 °C)
- High Dissolved Solid Nebulizers

Mining and Minerals - Lithium 610.346 nm



Sample Name	Sample Type	LI 610.346 %R
Blank IS	Standard 1	0.001
Standard 1	Standard 2	100%
Standard 2	Standard 3	100%
Standard 3	Standard 4	100%
Standard 4	Standard 5	94%
Standard 5	Standard 6	96%
Standard 6	Standard 7	102%
Standard 7	Standard 8	102%
Sample 1	Sample 2	44.0
Sample 2	Sample 3	10.3
Sample 3	Sample 4	10.3
Sample 4	Sample 5	23.1
Sample 5	Sample 6	23.1
Sample 6	Sample 7	23.1
Sample 7	Sample 8	23.1
Sample 8	Sample 9	23.1
Sample 9	Sample 10	23.1
Sample 10	Sample 11	23.1
Sample 11	Sample 12	23.1
Sample 12	Sample 13	23.1
Sample 13	Sample 14	23.1
Sample 14	Sample 15	23.1
Sample 15	Sample 16	23.1
Sample 16	Sample 17	23.1
Sample 17	Sample 18	23.1
Sample 18	Sample 19	23.1
Sample 19	Sample 20	23.1
Sample 20	Sample 21	23.1
Sample 21	Sample 22	23.1
Sample 22	Sample 23	23.1
Sample 23	Sample 24	23.1
Sample 24	Sample 25	23.1
Sample 25	Sample 26	23.1
Sample 26	Sample 27	23.1
Sample 27	Sample 28	23.1
Sample 28	Sample 29	23.1
Sample 29	Sample 30	23.1
Sample 30	Sample 31	23.1
Sample 31	Sample 32	23.1
Sample 32	Sample 33	23.1
Sample 33	Sample 34	23.1
Sample 34	Sample 35	23.1
Sample 35	Sample 36	23.1
Sample 36	Sample 37	23.1
Sample 37	Sample 38	23.1
Sample 38	Sample 39	23.1
Sample 39	Sample 40	23.1
Sample 40	Sample 41	23.1
Sample 41	Sample 42	23.1
Sample 42	Sample 43	23.1
Sample 43	Sample 44	23.1
Sample 44	Sample 45	23.1
Sample 45	Sample 46	23.1
Sample 46	Sample 47	23.1
Sample 47	Sample 48	23.1
Sample 48	Sample 49	23.1
Sample 49	Sample 50	23.1
Sample 50	Sample 51	23.1
Sample 51	Sample 52	23.1
Sample 52	Sample 53	23.1
Sample 53	Sample 54	23.1
Sample 54	Sample 55	23.1
Sample 55	Sample 56	23.1
Sample 56	Sample 57	23.1
Sample 57	Sample 58	23.1
Sample 58	Sample 59	23.1
Sample 59	Sample 60	23.1
Sample 60	Sample 61	23.1
Sample 61	Sample 62	23.1
Sample 62	Sample 63	23.1
Sample 63	Sample 64	23.1
Sample 64	Sample 65	23.1
Sample 65	Sample 66	23.1
Sample 66	Sample 67	23.1
Sample 67	Sample 68	23.1
Sample 68</		